



High Temperature Polymer Membrane Development at Argonne National Laboratory

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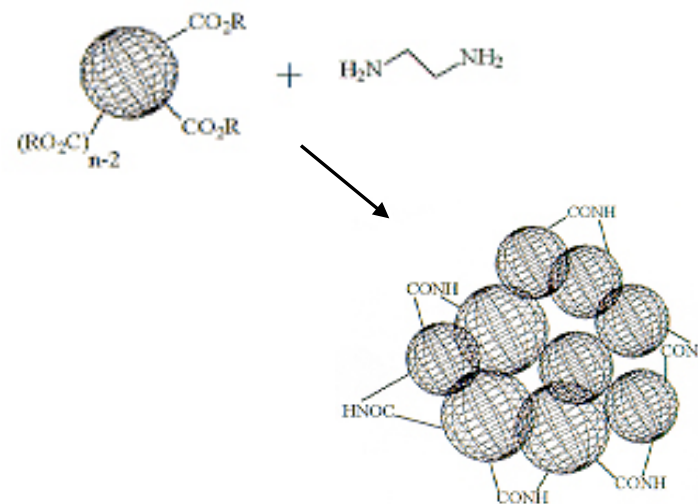
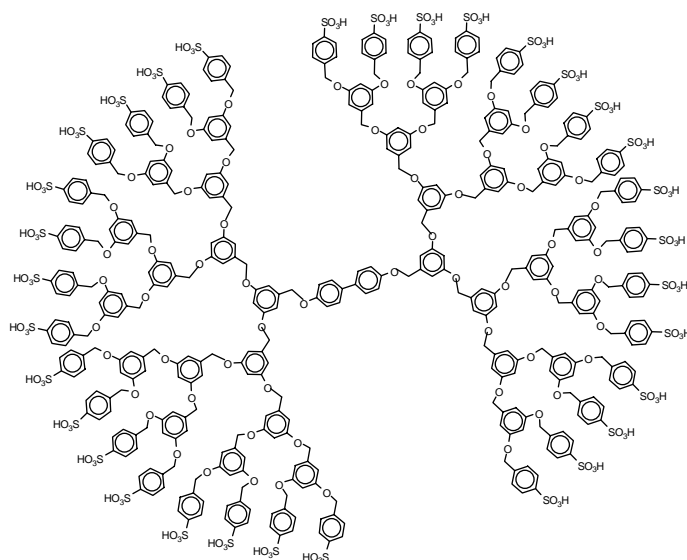


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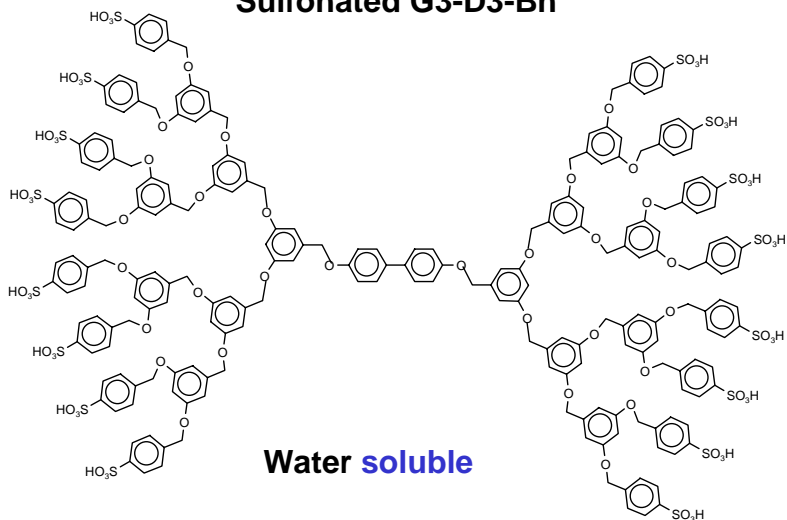
Approach: cross-linked dendrimeric polymers

- **Dendrimers are highly-branched spherical macromolecules**
- **High density of functional groups on dendrimer surface**
 - Low equivalent weight (250)
 - improves water retention at high temperatures
- **Membrane is a network of cross-linked dendrimers**
 - cross-linking eliminates water solubility and controls swelling
 - pore size can be controlled by length of cross-linker

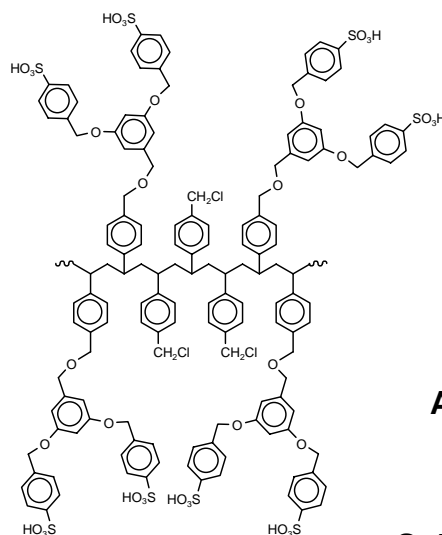


Interim Approach: Sulfonated Dendronized Polymers

Sulfonated G3-D3-Bn



Sulfonated PS-G1-Bn



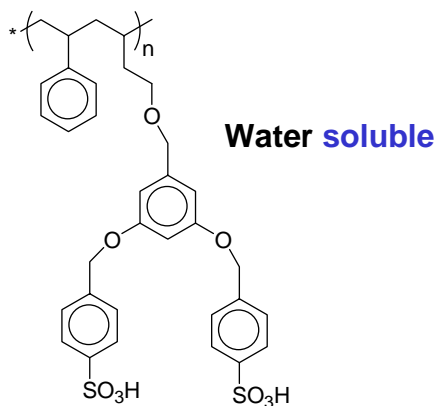
Type I ~ Slightly crosslinked
with equimolar ClSO_3H

Type II ~ Slightly crosslinked
with 3 equimol. excess ClSO_3H

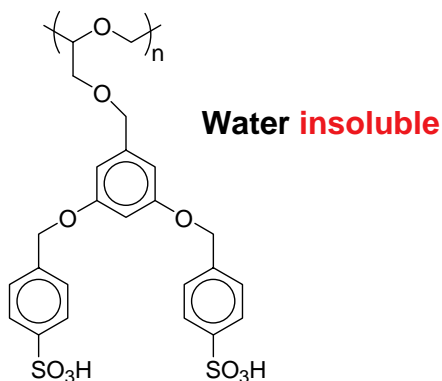
Type III ~ Non-crosslinked
with equimolar ClSO_3H

All of them are water **insoluble**

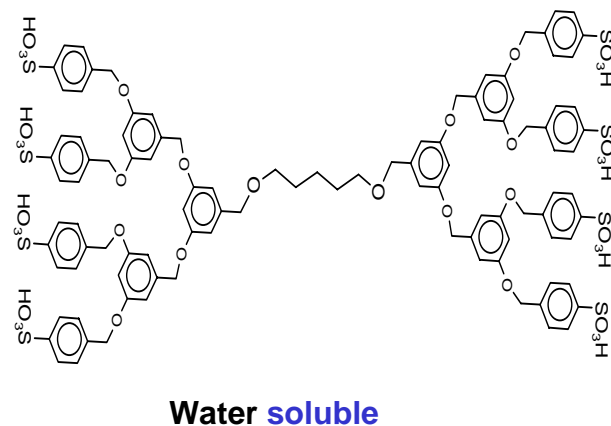
**Sulfonated
Poly(styrene-co-allyl alcohol)-G1**



**Sulfonated
Polyepichlorohydrin-G1 and G2**

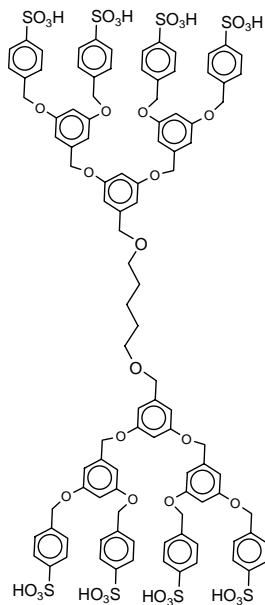


**Sulfonated aliphatic core
G2-D3-Bn**



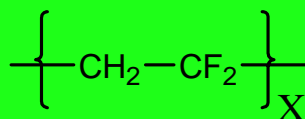
Interim Approach: Dendron-PVDF Blends

Sulfonated aliphatic core
G2-D3-Bn



Solution blending in NMP

KYNAR PVDF homopolymer



KYNAR 741

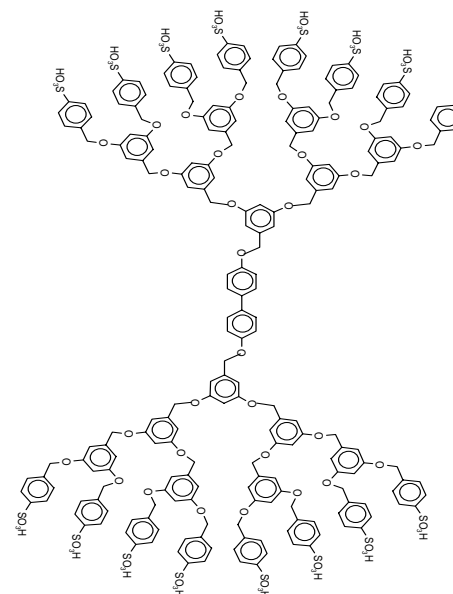
Tape casting

Drying under vacuum at 80°C

Rolling

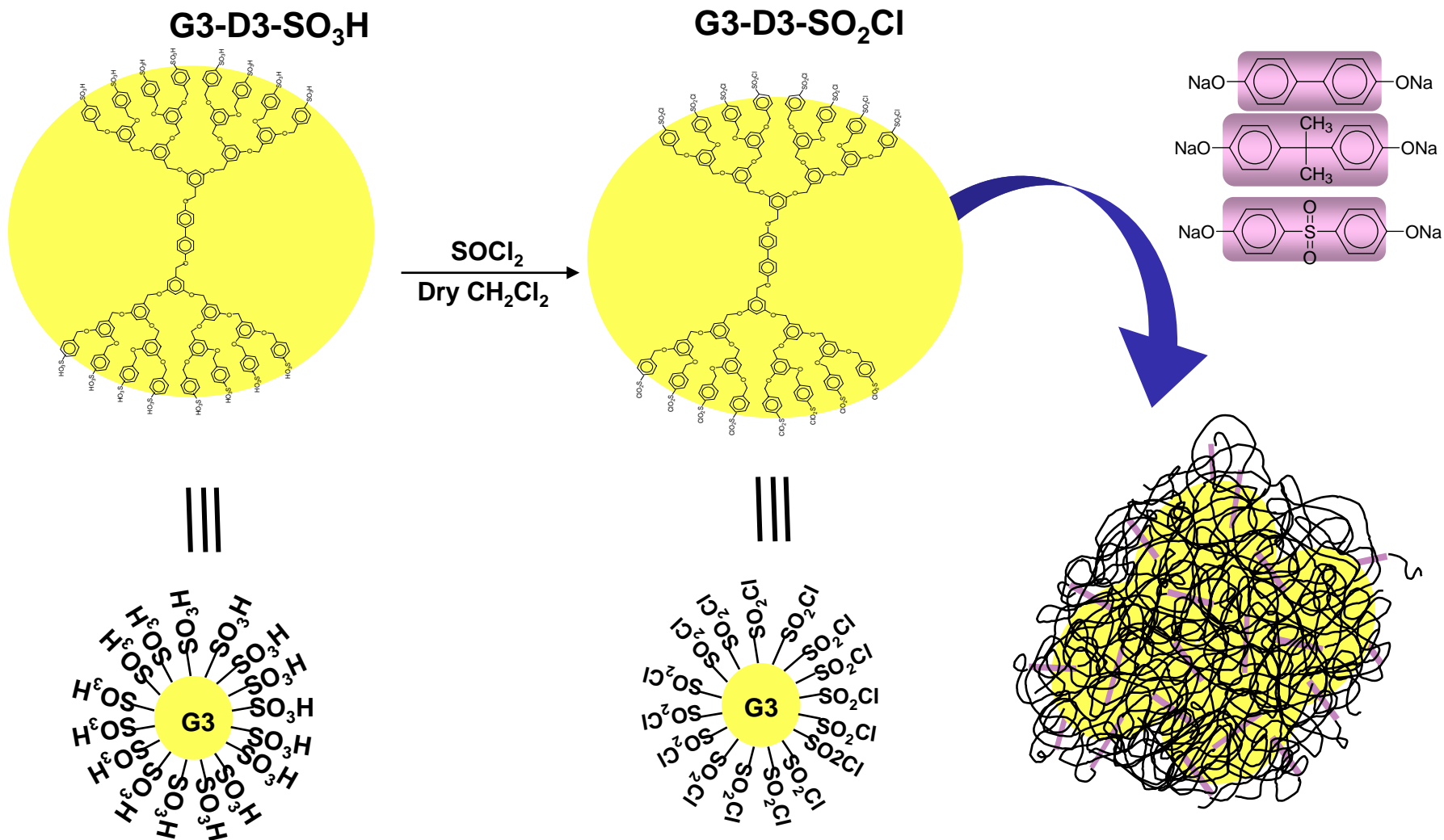
Membrane

Sulfonated G3-D3-Bn



PVDF-G3sulf at 69 °C : 0.01 S/cm
at 85 °C : 0.002-0.005 S/cm

Crosslinking of Dendrimer



Status

- **Dendrimer macromolecules have been prepared**
 - Have prepared G1, G2, and G3 sulfonic-acid terminated dendrimers
- **Polymer membranes have been prepared by attaching sulfonated dendrimer macromolecules to polymer backbones or blending with polymers**
- **TGA shows membranes are thermally stable up to 240°C**
- **Initial conductivity results:**
 - **0.101 S/cm at 76°C and 6% relative humidity** for polyepichlorohydrin-G2-sulfonated polymer
- **Beginning cross-linking of dendrimer macromolecules**